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Full Length Research Paper

Behavior of impervious facing system in zone semi arid in absence of the thermal protection Bouhnifia dam (Algeria)

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The bituminous concrete mask was the water barrier system of Bouhnifia dam "Algeria". It was applied on the upstream slope. The mask risked to be unstable because of the sunlight temperatures which can reach (65°C). So, it was covered with a thermal protection which demands a periodic renovation. This solution was very expensive. To avoid these costs, one tried to test the stability of the mask without the thermal protection. One prepared a reduced sample of the mask. Then, one put this sample on an inclined facing of 1/1 (slope of the Bouhnifia dam); and maintained it in an oven during more than 48 h under a temperature of 70°C. This experience permitted to determine that the sample kept its initial shape. The gotten results confirmed that the mask of the Bouhnifia dam can resist the action of the temperature without the necessity of the thermal protection.

Key words: Dam, water barrier, upstream mask, bitumen, bituminous concrete.

INTRODUCTION

A bituminous concrete face has been historically a real alternative solution as a water barrier for dam. Baron Van Asbeck reported the oldest known dam with a sort of primitive bituminous concrete facing to be ASSURE, constructed circa 1300 years BC in Mesopotamia. That is most significant, because it gives testimony to the antiquity of the design concept. Modern construction using bituminous concrete facings starts with CENTRAL dam built in the United States in 1910. In the last sixty years more than 300 dams of height of 30 m and reservoirs of height more 15 m, their water barrier were assured by the bituminous concrete.

The experience of the use of bituminous concrete upstream facing is little widespread in Algeria: Ghrib dam (1926 to 1938), Bouhnifia (1930 to 1941) and Sarno (1947 to 1954). The water barrier system of the embankment dam of Bouhnifia has been achieved by a flexible and insulated upstream Mask made of bituminous concrete of 12 cm of thickness placed on the upstream slope (Belbachir, 1973; CFGB, 1973).

The problem posed in the Bouhnifia dam is especially delicate because of the instability of the mask which was covered with a thermal protection, this last is also constituted by a layer of cement concrete of 10 cm thick, armed with a fencing wire of galvanized steel, The necessity of the renovation of the protective layer after every crack influenced on the total cost of the project.

The Objective of the study in the present work is to avoid the setting up of two layers (sealing layer and thermal protective layer) and to minimize the costs of

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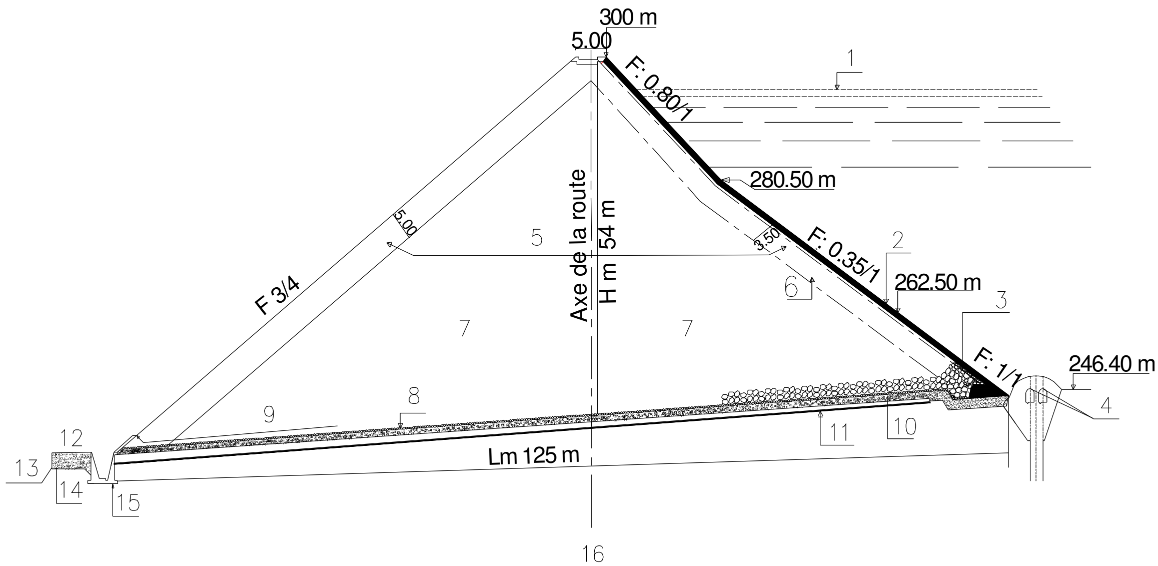

Figure 1. Cross the mask Bouhnifia dam. 1 - Hold Normal: 295.00 m. 2 - Mask tight. 3 - Masonry hourdée permeable gravel to concrete. 4 - Galleries and drainage work. 5 - Loose stones neatly arranged. 6 - Sitting slightly raised decrease the. 7 - Rock boulders secured step. 8 - Layer masonry. 9 - Berm for listing 248.00 m. 10 – Filter. 11 - Drain Bonna. 12 - Pavement. 13 - Filter. 14 – Murette. 15 - Cambre colature of drainage. 16 - Layer Oliocène.

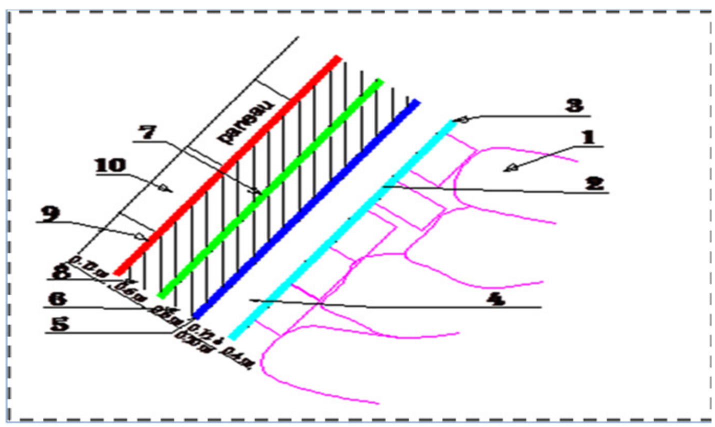

Figure 2. Structure of the mask seal. 1-Rock. 2 - Reinforcement. 3 - Coating mortar. 4 - Concrete Buidling the drainage layer. 5 - Hinge bitumen dissolved in gasoline. 6 - to 1st layer waterproof asphalt concrete. 7 - Filler bitumen fluxed with gasoline. 8 - 2nd sealed asphalt concrete layer. 9 - Paper interposed to prevent contact between the front mask and the barrier layer.

realization. So we studied the mechanical and physical behavior of a reduced sample of the mask under a temperature of (+65°C) without thermal protection.

Features of the dam

The main features of the dam and the structure of the bituminous concrete facing are given respectively in Figures 1 and 2.

METHODOLOGY

Formulation of the bituminous concrete

The study of the composition of a bituminous concrete mask consists of choosing among the economically available materials: aggregates with big elements, thin elements, filler as well as a quantity of bitumen to constitute a steady and impervious material

Table 1. Features of bituminous concrete facing of Bouhanifia dam.

Feature	Grain diameter (mm)	Percent (%)
Gravel	18/25	20.54
	12/18	14.65
	5/12	19.96
	2.5/5	6.75
Sand	0.63/2.50	10.17
	0.28/0.63	13.90
	0.1/0.28	4.28
Filler	Smaller than 0.1	9.75
Bitumen	Penetration 80/100	8% by weight of dry materials

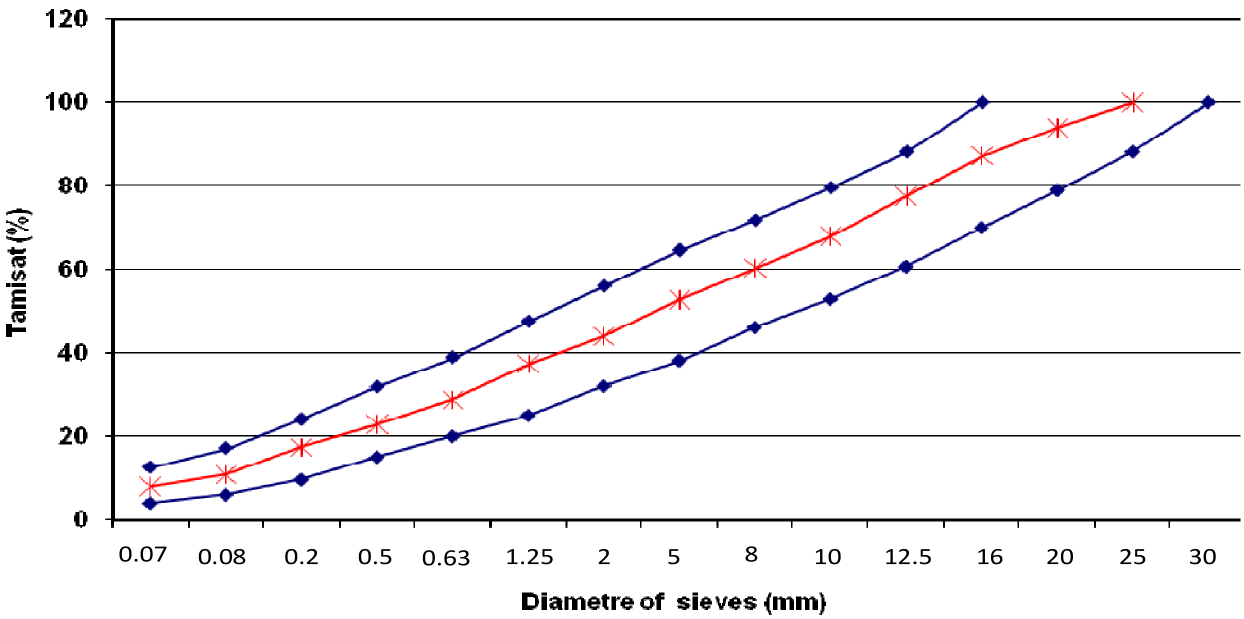

Figure 3. Grading curve of the mixture (gravel, sand and filler). From 0.01 mm to 30 mm diameter sieve. 0 to 100%: percentage of underflow. Time recommended size. Grading curve of the mask tight dam Bouhnifia.

compaction (Table 1, Figure 3). The voids must be filled of bitumen to achieve the imposed limits of practical considerations, a specific weight as high as possible (Asbeck, 1994).

Features of the used materials

Coarse aggregations

We call big aggregations all aggregates retained on the sieve N 10. These aggregates are constituted by rolled gravel, stones or milkmen ground.

Fine aggregates

We call by fine aggregates all the aggregates passing in the sieve n°10 and retained to the sieve N 200. These aggregates are constituted by natural sand or crushing or by a mixture of these two materials.

Filler

We call filler all materials passing in the sieve °200 and constituted by dry chalky fine grains, or cement, or by all other fine and inert material.

The aggregations must not be dismayed by the bad weather, not to be frost-susceptible, clean and exempted of dusts in excessive quantity, of homogeneous quality and must not include more than 5% of elementary flat; they must possess a good affinity for the bitumen ICOLD (1999). The physical characteristics of the aggregates are given in Table 2.

Bitumen

The bitumen is gotten by refinement of oils. They must be of homogeneous composition, exemption of water, and must be in

Table 2. Physical features of aggregates "mixing" and bitumen.

Number of samples	Specific gravity (t/m^3)	Sand equivalent (%)	Index penetration	Softening point
03	2.66	77.33	84	51°

conformity with some specifications. The used bitumen is characterized by: the penetration index and Softening point Table 2.

In view of the previous study of searching the best composition to adopt for the confection of the recommended spoiled, one determines: the apparent density; the percentage of the voids occupied by the air; the percentage of the voids of the aggregations and the percentage of the voids occupied by the bitumen (Arrambide et al., 1959).

Mixing and preparation of the samples

(i) We weigh successively the fixed quantities of different composing aggregates, these quantities must be calculated for a spoiled from 1000 to 1200 g, (binder not included).
(ii) We carry the container and its content in an oven adjusted in 140°C during one hour. In another container, we put the quantity of the binder; we heat it to a temperature between 140 and 160°C during 30 to 45 min in order to confer it to the necessary fluidity of the coating without attending the temperature where the spraying of oils would become excessive.
(iii) Immediately retired from the oven, the aggregations are poured in the binder's container. We add the filler, which does not need to be heated, but it must be dry. The mixture is introduced in a normalized mixer and it is homogenized during 30 min.
(iv) We fill the molds, while packing every time with the spoon; we adjust the full cylinder and we carry it all between the trays of press. The samples are compacted by 50 strokes. For the aim of letting the samples cool, it is is kept during 24 h in the ambient temperature.
(v) We measure to the slide gauge, to the 1/10 of mm meadows the diameters and the heights of the samples and we weigh them at 0.5 g meadows (Photo 1).

Determinations of the properties of the bituminous mixing "samples"

After verification of the features of the formulated bituminous concrete, we undertook the following tests: the compression resistance; the percentage of imbibition; the percentage of inflation; the stability following Marshall after immersion during 14 days; the permeability and the stability on the slope (Asbeck, 1994; Wappro, 1973).

The compression resistance

After confection of the samples, these are immersed in baths under temperatures 0, 20 and 50°C during 3 h. The samples are withdrawn from the baths and are immediately placed between the trays of the press. The compressive test has been driven on cylindrical samples with a press of capacity 1500 KN.

Percentage of imbibition

Two samples in view of calculation of the imbibitions (Photo 1). The percentage of imbibition calculates from the following formula:

$$\left(\frac{P_h - P_o}{P_o}\right).100 \quad (1)$$

In which:
Ph: Weight of the sample moistened after 14 days,
Po: Weight of the sample before the immersion.

Percentage of inflation

The same samples immersed under water during 14 days to the same temperature are measured to determine the inflation. The percentage of inflation is calculated according to the following formula:

$$\left(\frac{V_h - V_o}{V_o}\right).100 \quad (2)$$

In which:
V_O and Vh: are respectively the volumes of the samples before and after the immersion during 28 days.

Stability following Marshall after immersion during 14 days

The stability of the samples is determined after 14 days of conservation under water to the ambient temperature with the Marshall device (Photo 2).

Permeability

The seal is the fundamental quality of a mask; all samples have been tested under a water pressure of 6 kg. They are all stayed sealed after 24 h of contact. The value of the favorite permeability must be lower to the recommended value of 5.10^{-8} cm/s (Belbachir et al., 1973; Asbeck, 1994).

The coefficient of permeability is calculated with the following relation:

$$K\ (cm\ /\ s) = \frac{q \times l}{h \times f} \quad (3)$$

In which:
q: debit of flight of (cm^3/s),
l: the thickness of the plate of (cm),
h: pressure of (cm) of water, measured since the lower face of the plate,,
f: surface of the sample of (cm^2).

Verification of the stability on the slope

To verify the stability of the bituminous coatings put on slope, some samples put on an inclined support of 1/1 (slope of the Bouhanifia dam), and placed in an oven during 48 h under a temperature of 70°C (Photo 3), the samples must distort during the test

Photo 1. Sections of the samples.

Photo 2. Marshall test.

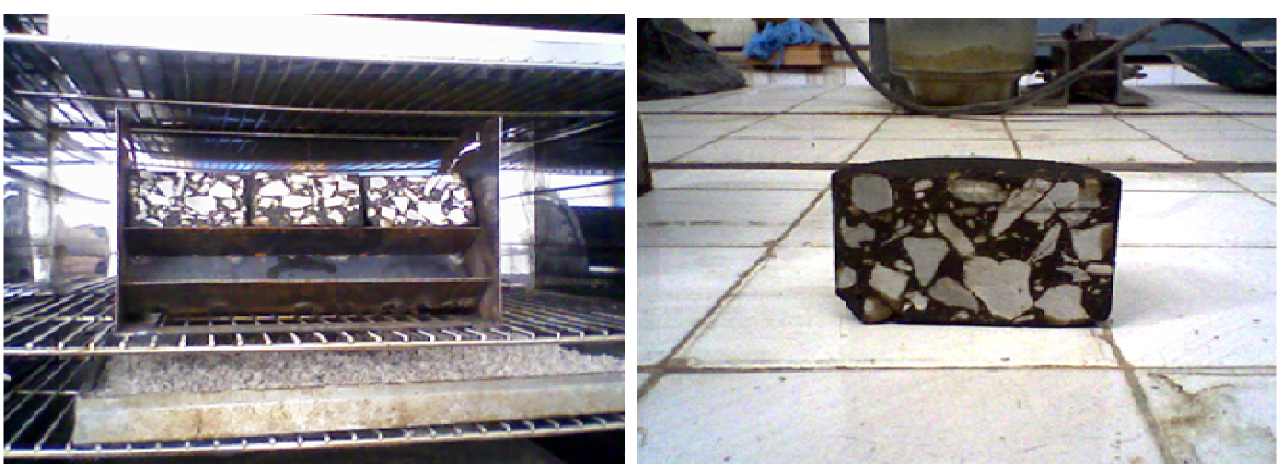

Photo 3. Specimens after storage 48 h in the oven.

Table 3. Results for Bouhnifia mask.

Studied characteristics	Mean obtained values	Recommended values
Density (g/cm^3)	2.39	Maximal
Creep (mm)	2.72	≤ 8.0
Stability (KN)	8.00	≥ 6.0
% Air voids	1.75	(1.5-2.3)
% Aggregate voids	21.68	> (16-19) %
Compressive strength R20 (kg/cm2)	79.62	> 30
Compressive strength R50 (kg/cm2)	19.90	> 15
Coefficient of thermal stability K_t	4.00	> 2.5
Flexibility coefficient K_e	1.50	< 2.8
Imbibition percentage (%)	0,39	< 1.50
Percentage of swelling Percentage of swelling (%)	0.39	< 0.5
Marshall stability after immersion 28 days.	9.50	> 5.4
Permeability (cm/s)	$4.10.10^{-8}$	5.10^{-8}

Table 4. Results for Sourani mask.

Studied characteristics	Mean values obtained	Recommended values
Density (g/cm^3)	2.282	Maximal
Creep (mm)	8.170	≤ 8.0
Stability (KN)	7.372	≥ 6.0
% Air voids	1.66	(1.5-2.3)
% Aggregate voids	21.597	> (16-19) %
Compressive strength R20 (kg/cm2)	55.09	> 30
Compressive strength R50 (kg/cm2)	20.15	> 15
Coefficient of thermal stability K_t	2.735	> 2.5
Flexibility coefficient K_e	2.29	< 2.8
Imbibition percentage (%)	0,33	< 1.50
Percentage of swelling Percentage of swelling (%)	0.038	< 0.5
Marshall stability after immersion 28 days.	6.70	> 5.4
Permeability (cm/s)	$6.20.10^{-8}$	5.10^{-8}

(Asbeck, 1994; Wappro, 1973). The results of the tests are presented in Table 3.

RESULTS AND DISCUSSION

According to the (Figure 3) we noticed that the grading curve of the mixture was registered in the recommended spindle which gave us a correct composition and allowed to reduce the percentage of the voids in the mixture. This last was the most important characteristic in the bituminous concrete, because it assured its permeability and durability. It also protected the bituminous concrete from the outside effects, that's why we gave a lot of importance for that characteristic (one tried to reduce to the maximum the percentage of the voids occupied by air). The advisable value was between (1.5 and 2.3%). For our case one found 1.75 which is in the norms. For the percentage of the voids between the grains, the advisable value must be superior to (16 to 19%) and lower to 22%. According to the Table 3, we noticed that the 21.68% respected the advisable norms. Following the found results, one noticed that all securities levels were in the norms and in the limits of the advisable securities.

Finally, concerning the verification of the stability of the samples on the tilted slope, which is the purpose of this research we found that, After the 48 h of conservation, the samples kept their initial shapes which allowed us to determine that the bituminous concrete facing resisted indeed the elevated temperatures without risking of deforming.

Researches made in this topic concerning the stability of the bituminous concrete upstream facing of the dam of Syria Sourani by Dr Djimili (Mr. of Conferences, University Badji-Mokhtar, Annaba, Algeria) in collaboration with Dr CHIBLAK, Professor, University of

Damascus, Damascus, Syria. In a work Thesis of Doctorate. University of Batna, Algeria, 2006, have Gave memes observations which are presented in Table 4.

Conclusion

The major problem of such type of mask is the elevated temperature on the surface. But according to the tests that we did and the gotten results, we can say that the bituminous concrete mask of the Bouhnifia dam resists a temperature of 70°C in spite of the absence of the thermal protection.

The bituminous concrete mask is certainly the easiest solution. It is the most economic way for the perfect slaking of embankment dams.

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